BIOCHEMISTRY OF PLANT DISEASES[1]

IV. PROXIMATE ANALYSIS OF PLUMS ROTTED BY SCLEROTINIA CINEREA

J. J. Willaman and F. R. Davison

(WITH TWO FIGURES)

In the third paper of this series (6) the literature bearing on the chemistry of plant diseases, especially the effect of disease on the composition of plants and the chemical differences between resistant and non-resistant varieties of the same species of plant, was reviewed in some detail. Since the present work is a continuation of the former, it will not be necessary to make reference again to the results of other investigations, except incidentally during the discussion.

In the previous work on the brown rot of plums, caused by the fungus *Sclerotinia cinerea*, it was found that during the progress of the rotting the H-ion concentration of the sap increases markedly; that oxalic acid is produced, but hardly in sufficient quantity to account for the increased acidity; that tannin decreases during the rotting; that protein nitrogen increases, due probably to the protein formed in the fungus mycelium. Resistant varieties did not differ conspicuously from non-resistant varieties, so far as the analyses showed, except that the resistant varieties usually had a more acid sap, and that more oxalic acid was produced in them. The tannin content of green plums usually increases after picking from the tree, but infection by *Sclerotinia* entirely inhibits this increase.

Experimentation

In the present work the ordinary proximate analyses, together with the determination of calcium, were made, using four varieties of plums at three stages of maturity, grown at the University Fruit

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Breeding Farm at Excelsior in 1918.[2] In table I are given the data concerning the samples.

PREPARATION OF MATERIAL.—The plums were halved or quartered, freed from the pits, and placed in ovens at about 90°–95° C. until dry enough to grind. It was not thought necessary to use special precautions in drying, considering the nature of the analyses to be made. The finely ground material was stored in bottles. The plums were rotted by sterilizing in mercuric chloride solution, and then inoculating with a suspension of spores by means

TABLE I

DATA ON PLUM SAMPLES, 1918

Lab. no.	Variety	Abbreviation	Date picked	Stage of growth	Condition of fruit	No. of days required for rotting	Texture of rotted fruit
	Resistant						
79...	Burbank×Wolf 9	B×W 9	July 2	I	Green, half grown	9	Firm
87...	Burbank×Wolf 9	B×W 9	Aug. 21	II	Fully grown, not ripe	12	Firm
91...	Burbank×Wolf 9	B×W 9	Sept. 3	III	Ripe	10	Fairly firm
80...	Abundance×Wolf 18	A×W 18	July 2	I	Green, half grown	12	Firm
88...	Abundance×Wolf 18	A×W 18	Aug. 21	II	Fully grown, not ripe	9	Hard
92...	Abundance×Wolf 18	A×W 18	Sept. 3	III	Ripe	11	Firm
	Non-resistant						
81...	Compass	C	July 2	I	Green, half grown	6	Soft
89...	Compass	C	Aug. 2	II	Fully grown, not ripe	7	Soft and watery
93...	Compass	C	Aug. 8	III	Ripe	6	Soft
82...	Sand cherry×Formosa	SC×F	July 2	I	Green, half grown	6	Somewhat soft
90...	Sand cherry×Formosa	SC×F	Aug. 2	II	Fully grown, not ripe	7	Soft
94...	Sand cherry×Formosa	SC×F	Aug. 8	III	Ripe	6	Soft

of a hypodermic syringe, plunging the needle right to the pit. It required from eight to fourteen days for complete rotting, as shown by the tissue becoming dark brown throughout.

METHODS OF ANALYSIS.—The moisture content of each sample was carefully determined at the time the other analyses were made, by drying to constant weight in a vacuum at 60° C. For the ash determination, 2 gm. samples were incinerated in platinum dishes, and then heated in a muffle at 550° C. until constant in weight. The calcium was determined in the ash by the MCCRUDDEN method (3), which has proved to be very simple and accurate. The Official Methods (1) were followed for total nitrogen and ether extract,

[2] The writers' thanks are due to Dr. M. J. DORSEY for his courtesies in furnishing the samples.

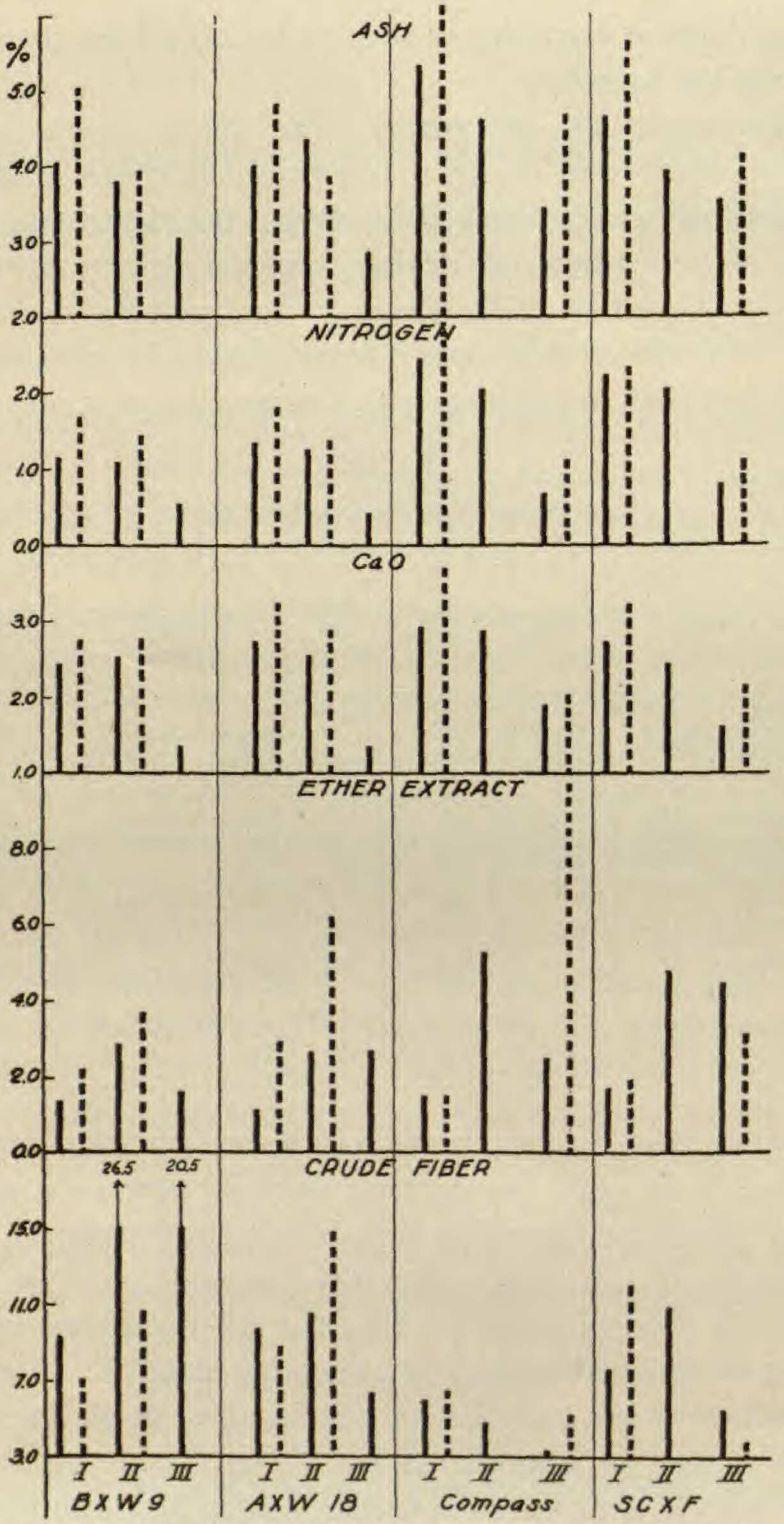

FIG. 1.—Composition of sound and of rotted plums of various varieties at three stages of growth: solid line, sound samples; dotted line, rotted samples; see table I for stages of growth and names of varieties.

and the KENNEDY (2) modification of the SWEENEY method was used for crude fiber.

Results

The data obtained in these analyses are shown graphically in figs. 1 and 2. All values are calculated to a moisture free basis. In fig. 1 the sound and rotted portions of each sample are placed side by side, so as to show the change in composition during rotting. It will be seen that in almost all cases the rotted portion shows a higher content of all constituents except crude fiber; the latter shows no general tendency in either direction, sometimes being greater and sometimes less in the rotted than in the sound material. The increase in these constituents is probably due to loss of dry matter through respiration. Previous work has shown that respiration is higher in infected than in sound plums, and this results in a relative increase in the substances determined. The figures for ether extract and for crude fiber are erratic in their changes, which is in keeping with the empirical nature of the methods of analysis.

In fig. 2 the same data are used, but they are arranged so as to give more direct comparison of varietal characteristics. The first

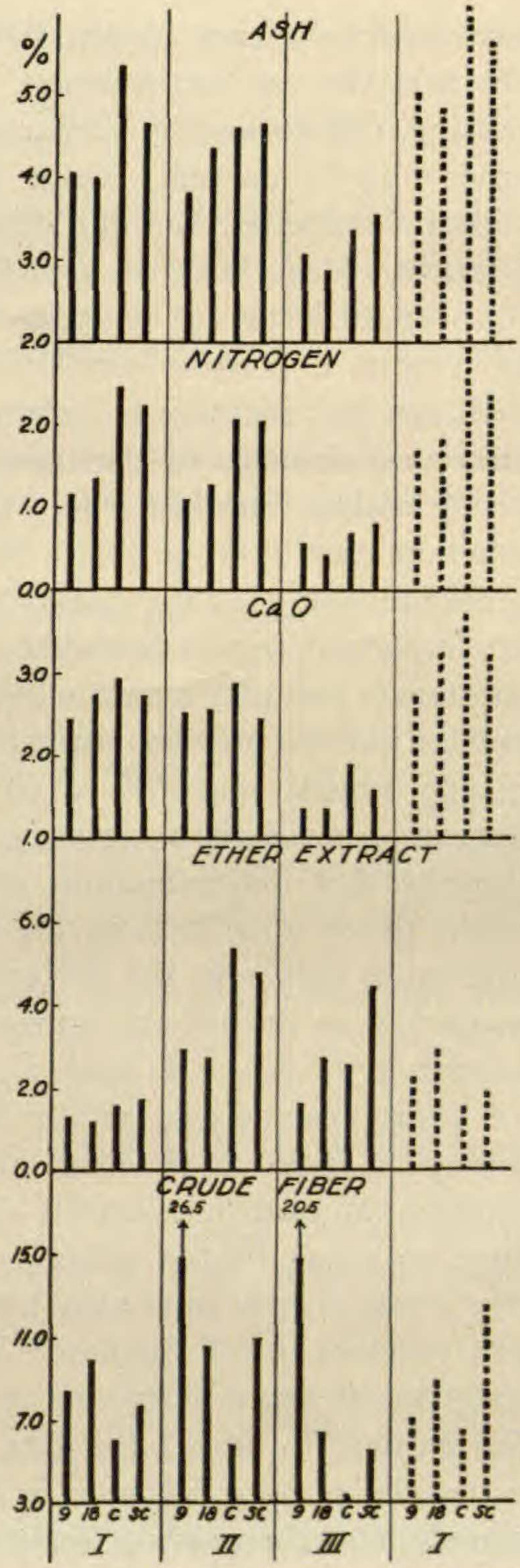

FIG. 2.—Composition of sound and of rotted plums, grouped to bring out varietal differences: solid line, sound samples; dotted line, rotted samples; first two varieties in each group are resistant to brown rot; second two are susceptible; see table I for stages of growth and names of varieties.

two varieties in each section, indicated by 9 and 18, are resistant; the next two are non-resistant. Some of the rotted samples are missing, due to loss by contamination. It will be seen that the crude fiber is markedly higher in the resistant than in the non-resistant varieties, but all other constituents are lower. This relation holds in both the sound and the rotted samples, although data for the latter are available for the first stage only. VALLEAU (4) reports a positive correlation between firmness of the plum flesh and its resistance to brown rot. The firmness is due to the structural elements of the tissue, the cellulose cell walls and the pectic middle lamellae. Only the former are represented in the determination of crude fiber. From the results at hand it appears quite probable that the quality and quantity of cellulose material are important factors in resistance properties, although the pectic substances also play a part in the metabolism of this fungus, as was pointed out in a previous paper of this series (5). In what ways the middle lamella may play a part in resistance properties is not known. Since it is a compound of pectin with calcium, it was thought that determinations of calcium in the present samples might throw some light on the question, but the data show that calcium is higher in the susceptible varieties in about the same magnitude as the ash and nitrogen, and no special significance can be seen in it.

In fig. 2 can be seen certain changes in the composition of plums during the course of ripening. As maturation progresses, the ash, nitrogen, and calcium steadily decrease. This is probably due to large increases in the soluble carbohydrates and organic acids. The crude fiber is somewhat higher in the second stage, which is just previous to full ripeness. The Compass variety is conspicuously low in crude fiber, and it is very susceptible to rotting by *Sclerotinia*. In table I the data on rate of rotting show the same tendencies as were discussed in the preceding paper of this series, namely, that the resistant varieties succumb to the rot much more slowly, and when rotted have a much firmer texture than the susceptible varieties.

Conclusions

1. Plum tissue that has been rotted by *Sclerotinia cinerea* is consistently higher in ash, CaO, nitrogen, and ether extract than

is the sound tissue. This is no doubt due to loss of dry matter by respiration in the rotted samples.

2. The resistant varieties are conspicuously higher in crude fiber than the susceptible. The quality and quantity of the structural elements of the tissues no doubt are important factors in their resistance properties. The ash, nitrogen, CaO, and ether extract are lower in the resistant varieties, but not sufficiently so to constitute limiting factors in the nutrition of the invading parasite.

3. As the ripening of plums proceeds, there is a decrease in the ash, nitrogen, and calcium content, due probably to storage of carbohydrates and acids.

Division of Agricultural Biochemistry
Minnesota Agricultural Experiment Station
St. Paul, Minn.

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